March 13, 1962 K. J. STALLER 3,025,436

HIGH CURRENT RECTIFIER

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Fig. 1

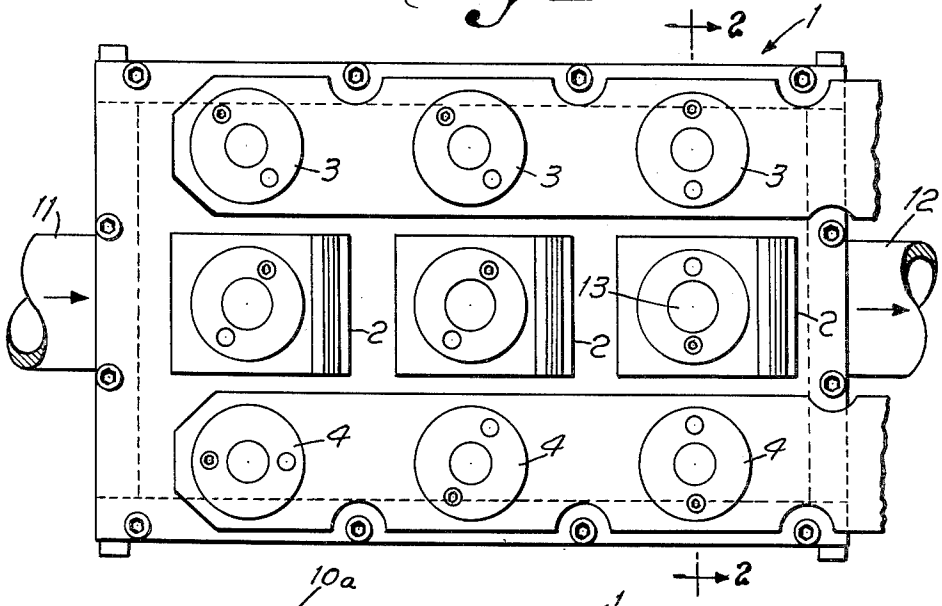
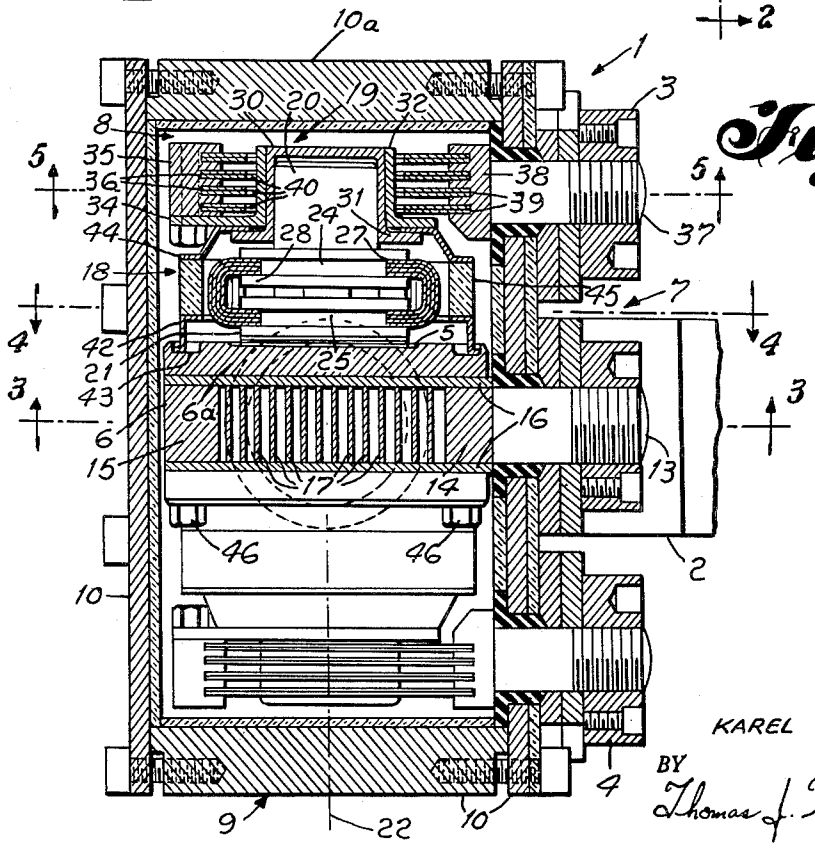


Fig. 2



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HIGH CURRENT RECTIFIER

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Fig. 3

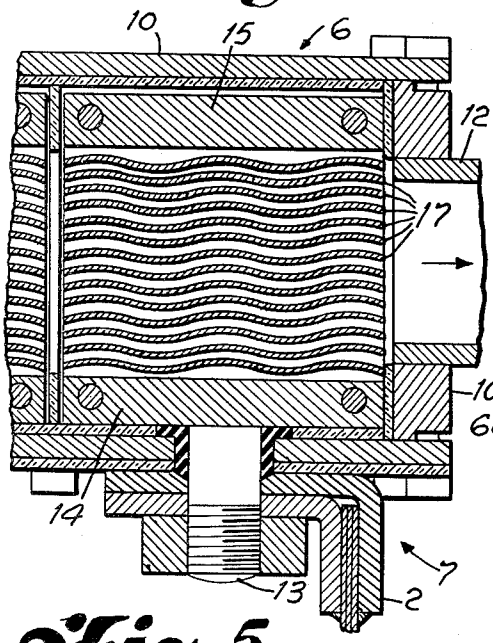


Fig. 4

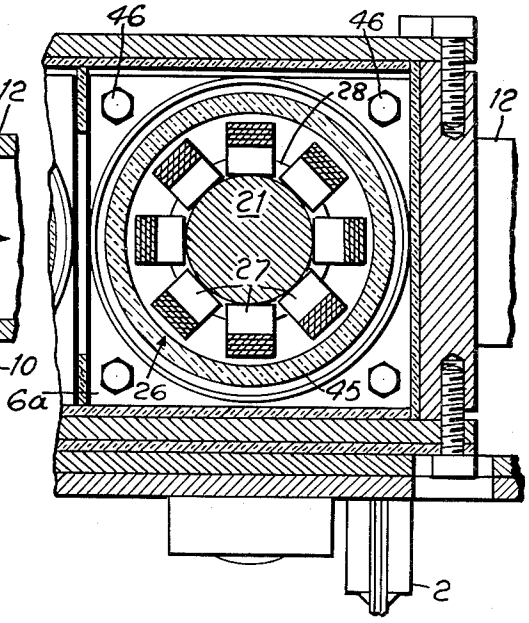


Fig. 5

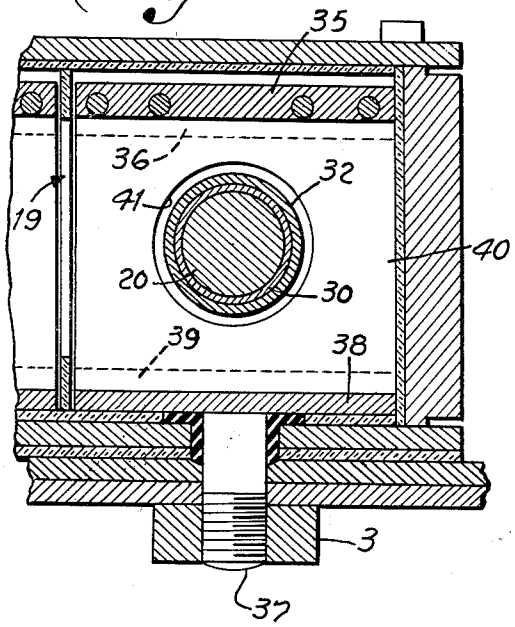
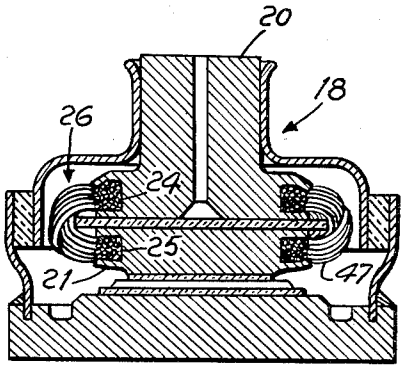


Fig. 6



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Fig. 7a

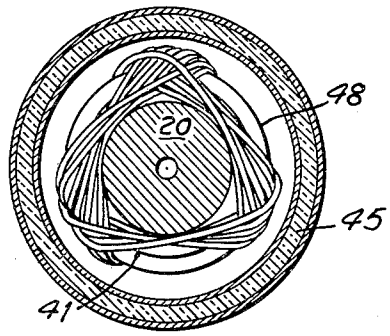


Fig. 8

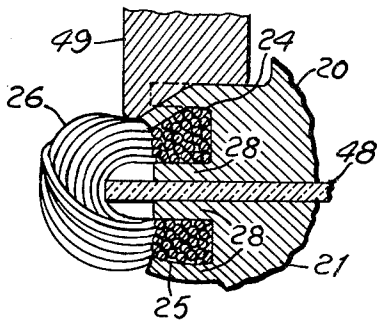


Fig. 7b

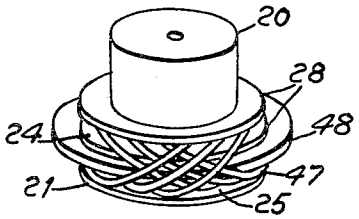


Fig. 9a

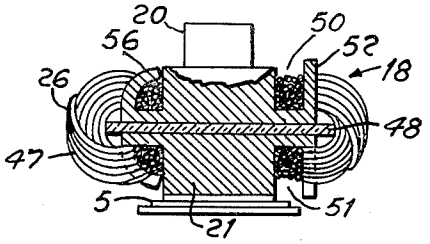


Fig. 7c

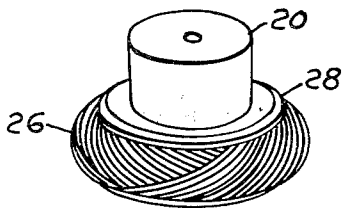


Fig. 9b

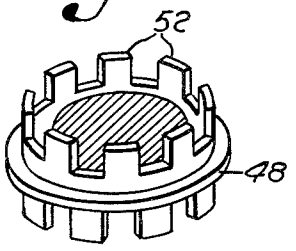
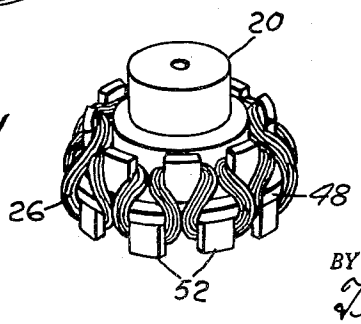


Fig. 9c



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United States Patent Office 3,025,436 Patented Mar. 13, 1962

3,025,436
HIGH CURRENT RECTIFIER

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Filed Aug. 19, 1959, Ser. No. 834,757
19 Claims. (Cl. 317—234)

This invention relates to semiconductive devices such as rectifiers and more particularly to high current, space saving, flexible electrical leads therefor.

One of the more severe limitations imposed upon the utilization of high current rectifiers in present day systems is the limitation as to use because of the large amounts of thermal energy generated by such devices. In this connection, one of the outstanding problems has been the dissipation of heat in the region of the rectifying element thus decreasing the danger of cracking of the rectification element due to expansion and contraction of the various parts when the rectifier is heated or cooled. The utilization of materials having like or near-like coefficients of thermal expansion has somewhat mitigated this problem but a particularly difficult problem remains with regard to variations due to thermal expansion at points where current carrying leads are connected to the rectification element. Conductive braids or multiwire cables have been utilized in the prior art by attaching them directly to the rectification element. The capacity of present day rectification elements for high currents, however, has often required the conductive leads of the rectification device to have a cross-sectional area which is close to or even greater than the cross-sectional area of the rectification element itself. (This is particularly true when it is desired to have high current carrying capacity as well as flexibility to make up for large thermal expansions.) Some prior art solutions to this problem have been to utilize coolants to minimize changes in dimension due to thermal expansion and to utilize flexible bellows to account for what expansion exists and to simultaneously provide an hermetic seal about the rectifying junction. These solutions require techniques which are costly in production, and utilize designs which are space wasting and heavy.

It is, therefore, an object of this invention to provide an improved high current semiconductor device with elastic leads of new type.

Another object of this invention is to provide a semiconductor device in which thermal expansion does not cause stresses in the brittle semiconductive element.

A further object of this invention is the provision of a flexible coupling assembly which is capable of carrying extremely high current, is capable of conducting thermal energy due to said high currents to cooling fins or a heat sink and is capable of compensating for changes in dimensions due to thermal expansions.

A still further object of this invention is to provide a novel liquid-cooled semiconductive assembly which provides for fullwave rectification of either single phase or three phase inputs.

A feature of this invention is the utilization of at least a pair of rectification elements in conjunction with a common heat sink structure which supports the elements and a resilient connection means utilized as either an input or output connection to allow for expansions and contractions of a resilient couplign assembly which is coupled between the rectification elements and the resilient connection means.

A feature of this invention is the utilization of a flexible coupling element adapted to engage recesses in spaced conductive members which are coupled to a rectifying element and to a conductive lead, respectively.

Another feature of this invention is the utilization of a

bowed, continuous, conductive filament, portions of which alternately engage recesses in the aforementioned conductive members; the filament being wound in overlapping manner circumferentially about the conductive members.

A still further feature of this invention is the utilization of a plurality of U-shaped conductive members which are utilized to flexibly interconnect two conductive members which have annular recesses disposed therein which are adapted to receive the ends of said U-shaped members.

The above-mentioned and other features and objects of this invention will become more apparent by reference to the following descritpion taken in conjunction with the accompanying drawings, in which:

FIG. 1 is an elevation view of a three-phase, liquid-cooled full-wave rectifier having expandable means for preventing stresses due to thermal expansion upon heating of rectification elements disposed therein.

FIG. 2 is a side view of FIG. 1, partly in elevation and partly in cross-section, showing the spatial relationships of the various elements.

FIG. 3 is a cross-sectional view of the common heat sink structure taken along lines 3—3 of FIG. 2.

FIG. 4 is a cross-sectional view of a resilient coupling assembly showing a flexible coupling element taken along lines 4—4 of FIG. 2.

FIG. 5 is a cross-sectional view of a resilient output assembly taken along lines 5—5 of FIG. 2.

FIG. 6 is a cross-sectional view of a halfwave rectifier showing an alternative embodiment of the resilient coupling assembly of FIG. 2.

FIGS. 7*a*, 7*b*, 7*c* show, in plan and elevation, the manner of forming a resilient coupling assembly from a conductive filament in accordance with the teachings of this invention.

FIG. 8 is a partial cross-section view of a flexible conductive element interconnecting two conductive members by bending a portion of the recess wall in clamping relationship about the flexible element.

FIGS. 9*a*, 9*b*, 9*c* show in elevation and cross-section the manner of forming a resilient coupling assembly utilizing a conductive filament and a plurality of projections about which a conductive filament is intertwined.

Referring now to FIGS. 1 and 2, a semiconductor device 1 for the rectification of three phase power into direct current power of opposite polarities is shown. FIG. 1 indicates input terminals 2 to which a three phase alternating current may be applied and, further, shows output terminals 3 and 4 from which direct currents of positive and negative polarity, respectively, may be obtained. The arrangement shown in FIG. 1 is, of course, not the only arrangement possible utilizing the teaching of this invention, but it has been shown as a three phase rectifier to indicate the versatility and utility of the structures to be discussed hereinbelow. It will, of course, be recognized that the arrangement shown in FIGS. 1 and 2 can be broken down into embodiments wherein only halfwave rectification of a single phase signal is required, or can be extended for utilization as halfwave and fullwave rectifiers for multiphase operation.

Since both portions of the fullwave rectifier of FIG. 2 are identical, it should be recognized that when reference is made to an element in the sectioned portions of FIG. 2, an identical element in the elevation view portion is also intended, the elements having the same relation one-to-the-other in each portion. In FIG. 2, a rectification element 5 is shown supported on one side thereof on a conductive, heat sink structure 6 which is made preferably of copper. Heat sink structure 6 is coupled on its other side to an input connection means 7 which, in FIG. 2, is adapted to apply an alternating current signal to the rectification elements 5. Output connection means, shown generally at 8, is coupled or attached to the other side of

rectification element 5 and due to the arrangement of rectification elements 5 the alternating current signal placed on terminal 2 is converted to a direct current signal of opposite polarities positive and negative, respectively, at terminals 3 and 4. Rectification elements 5 and their associated input connection means 7 and output connection means 8 are enclosed in a housing shown generally at 9 having walls 10 which define a given volume. Input and output pipes 11 and 12, respectively, introduce into and take from the given volume a dielectric coolant in which the semiconductive device 1 is completely immersed so that when operating as a rectifier the heat generated therein may be easily dissipated. Connection means 7, 8 have been designated as input and output means, respectively, but it is clear that the functions of these means could be interchanged without departing from the spirit of this invention.

Referring now to FIGS. 2 and 3, input connection assembly 7 is shown. Input connection assembly 7 includes a conductive stud 13, made of copper, which terminates a cross-member 14 which has a substantially rectangular cross-sectional area. A conductive spacer member 15, preferably made of copper, is disposed opposite to and in parallel relationship with cross-member 14 and forms a part of heat sink structure 6. Cross-member 14 and spacer member 15 are utilized to maintain a given spacing between conductive plates 16, and members 14 and 15 are positioned at the extremities of conductive plate 16 such that a given spacing is maintained between plates 16. In the space defined by conductive plates 16, cross-member 14 and conductive spacer member 15, a plurality of conductors 17 is disposed which may take the form of flexible conductive strips, made preferably of copper, so that the heat generated in rectification element 5 is conducted to heat sink structure 6 wherein the strips 17 present a large surface area over which coolant flows for the dissipation of heat. Flexible conductive strips 17 may be soldered to conductive plates 16 and the strips, as shown in FIG. 3, are corrugated to present a large surface area to the coolant and are disposed in substantially parallel relationship to each other. It should be noted that conductive strips 17 form channels which are substantially parallel to the direction of flow of coolant from pipe 11 to pipe 12.

Referring now to FIGS. 2, 4 and 5, a resilient output connection means, shown generally at 8 in FIG. 2, includes a resilient coupling assembly 18 and a conductor assembly 19 coupled to resilient coupling assembly 18. Resilient coupling assembly 18 shown in cross-section in FIG. 2 and in plan in FIG. 4 includes a first conductive member 20 which is made preferably of copper and is substantially cylindrical in shape. Resilient coupling assembly 18 further includes a second conductive member 21 attached to rectification element 5, made preferably of copper, and like member 20 is substantially cylindrical in shape. Both members 20 and 21 are concentric of a given axis 22 which is the axis of symmetry of rectification element 5. Conductive members 20 and 21 have annular recesses 24 and 25, respectively, disposed on the surfaces thereof and a conductive flexible element, shown generally at 26, has parts disposed in recesses 24, 25 such that members 20, 21 are held in interconnected relationship. In FIGS. 2 and 4, flexible element 26 consists of a plurality of U-shaped members 27, the legs of which engage recesses 24 and 25. In this connection, it should be noted that recesses 24 and 25 are bounded by radially extending portions 28 which may be bent, as will be shown hereinafter, to clamp the legs of U-shaped members 27 in recesses 24 and 25 to retain members 27 in a substantially fixed position. Thus, a plurality of U-shaped members 27 are disposed circumferentially about and interconnect conductive members 20 and 21 in such a way that a high current may be conducted between these members and, simultaneously, any expansions due to heating which might cause cracking of rectification element 5 are compensated for by the same means. Members 20 and 21 have been referred to hereinabove as having cylindrical shapes. This shape is preferred in that it provides for uniform expansions in every direction, but there is no reason why rectangular or square members could not be utilized and still remain within the teaching of this invention.

One method of obtaining flexible element 26 of FIGS. 2 and 4 is to wind a flexible copper strip about a rectangularly shaped mandrel such that one turn overlies the other. When the winding has reached a desired thickness, the winding is cut at the midpoint of the cross-section of the rectangular mandrel on both sides thereof providing two U-shaped members 27. The flexible conductor strip which is utilized to form U-shaped member 27 should be flexible enough to be easily shaped and enough layers should be wound so that when the member 26 results by cutting the rectangular winding on the mandrel, a certain amount of stiffness should be present so that members 20 and 21 are held in spaced relationship from each other. Other embodiments which are equally useful will be described hereinbelow in connection with FIGS. 6, 7 and 9.

Referring now to FIGS. 2 and 5, a conductor assembly, shown generally at 19, may be seen. Conductor assembly 19 includes a cap 30, made of conductive material such as copper, coupled about a portion of conductive member 20. Cap 30 is a hollow cylindrical member closed at one end and has a radially extending flange 31 at the other end thereof. In FIG. 2 a conductive sleeve 32, made of copper, is shown disposed conformally about cap 30 and its cylindrical shape is force-fit to the cylindrical shape of cap 30. Conductive sleeve 32 has a flange 33 at one end thereof such that flange 33 and flange 31 are disposed adjacent each other. Flange 33 has a portion 34 which extends further in a radial direction than the remainder of flange 33 and this portion 34 is utilized to support a conductive retaining element 35. Conductive retaining element 35 is a substantially rectangular conductive member having slots 36 extending lengthwise of retaining element 35. Conductor assembly 19 also includes a fixed conductive output stud 37 which terminates at one extremity in a cross-member 38. Conductive retaining element and cross-member 38 are disposed on opposite sides of conductive sleeve 32 and cross-member 38, like retaining element 35, has slots 39 disposed lengthwise thereof and opposite slots 36. In FIGS. 2 and 5, a plurality of flexible conductive leads 40 are shown interconnecting conductive retaining element 35 and cross-member 38, the extremities of flexible conductive leads 40 terminating in slots 36 and 39 of elements 35 and 38, respectively. Flexible conductive leads 40 may be made of a number of thin sheets of copper laminated to form a lead 40. Each flexible conductive lead 40 has an aperture 41 contained therein to prevent leads 40 from coming into contact with sleeve 32. In this way, then, alternating current entering a terminal 2 is applied through input means 7 through heat sink structure 6 to rectification element 5. Rectification element 5 which may consist of silicon having some desired impurity disposed therein to form a rectifying junction is sandwiched between two molybdenum discs, one of which forms a portion of heat sink structure 6 and the other of which forms a portion of member 21 to provide for good heat conductivity between rectification element 5 and conductive member 21 and heat sink structure 6. Rectification element 5 rectifies in a manner well-known to those skilled in the art and the rectified current passes from the rectifier through conductive member 21 to conductive member 20 by means of conductive flexible elements 26. The current then passes from conductive member 20 through cap 30 to conductive sleeve 32, from whence it enters conductive retaining element 35; is conducted to cross-member 38 through flexible conductive leads 40 to output stud 37 and from thence to output terminal 3. A consideration of the foregoing indicates that thermal expansions

due to heating at the rectification element 5 are compensated for by U-shaped members 27 and that further expansions due to heating are compensated for by flexible conductive leads 40 in such a way that conductive member 20, cap 30, and conductive sleeve 32 can move relative to fixed output 37 without danger of putting undue mechanical stresses on this terminal. Again, it should be noted that the configuration of leads 40 and strips 17 aid in cooling semiconductive device 1 by presenting larger surface areas over which the coolant introduced may flow. In this way, the rectifier is quickly cooled and the volume of coolant required is most efficiently utilized.

Referring again to FIG. 2, rectification element 5 is hermetically sealed by means of a flexible member 42, one end of which fits into a groove 43 on heat sink structure 6*a*. A second flexible member 44 is welded or soldered between the flanges 31 and 33 of cap 30 and sleeve 32 and the other ends of flexible members 44 and 42 are connected by a ceramic to metal bonding technique to the upper and lower surface, respectively, of an annular ceramic ring 45. The combination of flexible parts 42 and 44 and ceramic ring 45 forms an enclosure about rectification element 5 which may be evacuated by means of tubulation, not shown, or which may have a gas or other substance disposed therein to prevent the accumulation of moisture and other undesirable impurities from forming on the surface of rectification element 5.

Because of the hermetically sealed arrangement just described, no coolant comes in contact with rectification element 5, U-shaped members 27 or with surfaces of conductive members 20 and 21. Heat generated at the rectifying junction 5, then, must be carried by conduction to heat sink structure 6 and to conductor assembly 19 where the coolant utilized flows in intimate contact with strips 17 and conductive leads 40. It is clear that the cooling must take place in this fashion since the radiation of heat through the hermetically sealed region is minimal.

It should be noted that the semiconductor device 1 is demountable and that any single rectification element, if burned out, can be easily replaced. Thus, by removing the upper wall 10*a* in FIG. 2 and by removing conductive retaining element 30, sleeve 32 and leads 40, the portion 6*a* of heat sink member may be removed from heat sink structure 6 by simply removing screws 46 as shown in FIG. 4. By reversing the process the device may be reassembled.

In FIG. 6 a resilient coupling assembly, shown generally at 18, consists of conductive members 20 and 21, which are interconnected by means of a conductive flexible element 23 which extends from recesses 24 and 25 in members 20, 21, respectively, in a bowed, semicircular configuration. Conductive flexible element 26 has been described as a U-shaped element 27 in connection with FIGS. 2 and 4 but it may be a continuous conductive filament 47 such as a copper wire, portions of which alternately engage recess 24 of conductive element 20 and then engages recess 25 of conductive element 21 in an overlapping manner. FIG. 7*a* shows a truncated portion of conductive element 21 of FIG. 6 and it is indicated therein how a conductive filament 47 is continuously wound in an overlapping manner. FIG. 7*b* clearly indicates how filament 47 passes from recess 24 to recess 25 and from thence back to recess 24 and so on circumferentially about recesses 24, 25 until the region between the slots in completely filled with a braid-like flexible member 26, resulting in an arrangement as shown in 7*c*. A flat circular element 48 is shown in FIGS. 7*a* and 7*b* disposed between conductive members 20 and 21. Element 48 is utilized to maintain a spacing between conductive members 20 and 21 during manufacturing and to provide a means whereby filament 47 may be tautly bowed as it is being wound from recess 24 in conductive member 20 to recess 25 in conductive member 21 circumferentially about these members. Circular element 48 may be in material which is capable of being dissolved in a fluid which does not react with the other elements utilized in the construction of semiconductor element 1. Thus, the element 48 may be made of a plastic which dissolves in acetone, or may be made of rock salt which dissolves in water. The sole purpose of flat element 48 is to maintain the filament 48 in a tautly bowed condition as it is wound circumferentially about conductive members 20 and 21 in recesses 24, 25, respectively.

In the aforementioned figures, it should be noted that grooves or retaining slots 24 and 25 are bounded by radially extending flexible portions 28 as shown in FIG. 8. FIG. 8 clearly indicates the bowed semicircular cross-section of flexible element 26 extending between recesses 24, 25. Spacer element 48 is shown maintaining the spacing between conductive members 20 and 21 and is further maintaining flexible member 26 in a tautly bowed condition. A tool 49, shown in FIG. 8, is utilized to bend radially extending portions 28 such that the portions of flexible element 26 which reside within slot 24 are tightly secured within the slot by the clamping action of radially extending portion 28 on portions of flexible element 26. By crimping or clamping radially extending portion 28 of member 21, in like manner, flexible element 26 is fixedly held within slots 24 and 25 and upon dissolution of spacer element 48 portions 20 and 21 are free to expand under mechanical or thermal stresses, thereby preventing cracking of rectification element 5 when semiconductive device 1 is heated or cooled.

Referring now to FIG. 9*a*, another structure, in accordance with the teachings of this invention, is shown. A resilient coupling assembly 18 similar to that shown in FIG. 7 is proposed with the exception that the recesses 24, 25 instead of having radially extending portions 28 now have recesses 50 and 51, which are bounded by vertically extending portions 52, portions of which are castellated or notched and adapted to receive and fixedly retain a flexible member 26 in interconnecting relationship with conductive members 20 and 21. The castellated or notched portions of vertically extending projections 52 are shown in FIGS. 9*a* and 9*b*, and FIG. 9*c* indicates how a continuous conductive filament 47 may be wound to engage recesses 50, 51 so that conductive members 20 and 21 in cooperation with flexible member 26, form a resilient coupling assembly 18.

As in the instance of FIG. 6, the spacer element 48 is dissolved away and the vertically extending portions 52 may be bent by a tool similar to that shown in FIG. 8 to tightly secure flexible element 26 in recesses 50 and 51. FIG. 9*a* shows how portions 52 may be bent to not only secure element 26 but also to insure good electrical contact between the various parts.

It should be understood that the grooves or retaining slots in conductive elements 20 and 21 need not be annular nor need conductive elements 20 and 21 have a cylindrical configuration. The configurations described in the foregoing paragraphs are, of course, preferred in that expansions and contractions due to heating are everywhere uniform when this configuration is utilized. However, a particular shape may be desired for a special purpose and it is obvious that the teaching of this invention may be applied to any configuration.

While I have described above the principles of my invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation to the scope of my invention as set forth in the objects thereof and in the accompanying claims.

I claim:

1. A semiconductor device adapted to have expansion and contraction characteristics during use comprising at least a pair of rectification elements, a common heat sink structure supporting each of said rectification elements, input connection means coupled to said rectification elements to apply an alternating current signal thereto, out-

put connection means coupled to each of said rectification elements, one of said connection means for each of said rectification elements being resilient to allow for expansion and contraction relative to said heat sink structure and means coupled between a given portion of each of said one of said connection means and said heat sink structure to hermetically seal said rectification elements.

2. A semiconductor device adapted to have expansion and contraction characteristics during use comprising at least a pair of rectification elements, a common heat sink structure supporting each of said rectification elements, input connection means coupled to said rectification elements to apply an alternating current signal thereto, and output connection means coupled to each of said rectification elements, one of said connection means for each of said rectification elements being resilient to allow for expansion and contraction relative to said heat sink structure, said heat sink structure including a copper block having at least a portion on one side thereof silverplated and a molybdenum disc having one side thereof disposed in contact with said silverplated portion and the other side thereof disposed in contact with one of said rectification elements, the other side of said copper block being coupled to one of said connection means.

3. A semiconductor device adapted to have expansion and contraction characteristics during use comprising at least a pair of rectification elements, a common heat sink structure supporting each of said rectification elements, input connection means coupled to said rectification elements to apply an alternating current signal thereto, and output connection means coupled to each of said rectification elements, one of said connection means for each of said rectification elements being resilient to allow for expansion and contraction relative to said heat sink structure, said input connection means including a conductive stud terminating in a cross-member at one extremity thereof, and said heat sink structure includes conductive plates coupled to said cross-member with said cross-member disposed between a portion of said plates thereby defining the space between said plates, and a plurality of conductors coupled between said conductive plates.

4. A device according to claim 1 wherein said output connection means includes a resilient coupling assembly, and a conductor assembly coupled to said resilient coupling assembly.

5. A device according to claim 4 wherein said resilient coupling assembly includes a first conductive member, a second conductive member attached to said rectification element, said members being disposed in spaced relationship with respect to each other, a flexible conductive element having parts disposed in conductive engagement with said members for interconnecting said members to permit relative movement between said members.

6. A semiconductor device adapted to have expansion and contraction characteristics during use comprising at least a pair of rectification elements, a common heat sink structure supporting each of said rectification elements, input connection means coupled to said rectification elements to apply an alternating current signal thereto, output connection means coupled to each of said rectification elements, one of said connection means for each of said rectification elements being resilient to allow for expansion and contraction relative to said heat sink structure, said output connection means including a resilient coupling assembly, and a conductor asesmbly coupled to said resilient coupling assembly, said conductor assembly including a conductive cap coupled about a portion of said first conductive member, a conductive sleeve coupled to and conformal with said cap, a conductive retaining element coupled to sleeve, a fixed conductive output stud and having a cross-member, said retaining element and said cross-member being disposed on opposite sides of said sleeve, and a plurality of flexible conductive leads interconnecting said cross-member and said retaining element thereby permitting relative motions between said fixed conductive output stud and said resilient coupling assembly.

7. A device according to claim 6 wherein said flexible conductive leads include a plurality of laminated copper sheets having an aperture disposed therein to avoid contact with said conductive sleeve.

8. A semiconductor device adapted to have expansion and contraction characteristics during use comprising at least a pair of rectification elements, a common heat sink structure supporting each of said rectification elements, input connection means coupled to said rectification elements to apply an alternating current signal thereto, and output connection means coupled to each of said rectification elements, one of said connection means for each of said rectification elements being resilient to allow for expansion and contraction relative to said heat sink structure, and means for directing the flow of coolant through said semiconductor device for cooling thereof.

9. A device according to claim 8 wherein said means for directing the flow of coolant includes a housing; the walls of which enclose said semiconductor device and define a given volume in which said semiconductor device is disposed, means coupled to said housing to introduce therein and take therefrom a dielectric coolant such that said semiconductive device is completely immersed in said coolant.

10. A device according to claim 8 wherein said means for directing the flow of coolant includes a plurality of passages disposed in said heat sink structure parallel to the direction of flow of coolant.

11. A semiconductor device comprising a plurality of pairs of rectification elements, each of said pairs of rectification elements having associated with it a pair of output terminals and a common input terminal, a heat sink structure coupled to said input terminal to support each of said rectification elements on one side thereof, resilient output means coupled between the other side of each of said rectification elements and associated one of said pairs of output terminals and means coupled between said heat sink structure and each of said output terminals to hermetically seal each of said rectification elements independently of each other.

12. A semiconductor device adapted to have expansion and contraction characteristics during use comprising a rectification element, means supporting said rectification element on one side thereof for direct heat dissipation, a resilient coupling assembly including a first conductive member, a second conductive member attached to said rectification element, said members being disposed in spaced relationship with respect to each other, a flexible conductive element having parts disposed in conductive engagement with said members for interconnecting said members to permit relative movement between said members, and means for securing said parts to said members, said flexible element including a bowed continuous conductive filament, portions of which alternately engage a recess of said first conductive member and then a recess of said second conductive member as said filament is wound in an intertwining manner about said conductive members.

13. A semiconductor device adapted to have expansion and contraction characteristics during use comprising a rectification element, means supporting said rectification element on one side thereof for direct heat dissipation, a resilient coupling assembly including a first conductive member, a second conductive member attached to said rectification element, said members being disposed in spaced relationship with respect to each other, a flexible conductive element having parts disposed in conductive engagement with said members for interconnecting said members to permit relative movement between said members, and means for securing said parts to said members,

said flexible element including a plurality of discrete U-shaped conductive elements, the leg portions of which are adapted to be conductively engaged by the recesses of said first and second conductive members.

14. A semiconductor device adapted to have expansion and contraction characteristics during use comprising a rectification element, means supporting said rectification element on one side thereof for direct heat dissipation, a resilient coupling assembly including a first conductive member, a second conductive member attached to said rectification element, said members being disposed in spaced relationship with respect to each other, a flexible conductive element having parts disposed in conductive engagement with said members for interconnecting said members to permit relative movement between said members, and means for securing said parts to said members, said last named means including an annular recess in the surface of each of said conductive members and means to clamp said parts in said recesses.

15. A device according to claim 14 wherein said recesses are bounded by radially extending portions, said portions being alterable to fixedly clamp said parts in interconnecting relationship with said conductive members.

16. A device according to claim 14 wherein said recesses are bounded at least in part by a series of projections, said flexible element being intertwined about said projections in interconnecting relationship with said conductive members.

17. A semiconductor device comprising a rectification element adapted to have expansion and contraction characteristics during use, a heat sink structure supporting said rectification element from one side thereof, a resilient coupling assembly including a first conductive member, a second conductive member attached to said rectification element, said members being disposed in spaced relationship with respect to each other, a flexible conductive element having parts disposed in conductive engagement with said members for interconnecting said members to permit relative movement between said members and means for securing said parts to said members, and means coupled between said heat sink structure and said first conductive member to hermetically seal said rectification element.

18. A semiconductor device adapted to have expansion and contraction characteristics during use comprising a rectification element, a heat sink structure supporting said rectification element, input connection means coupled to said rectification element to apply an alternating signal thereto, output connection means coupled to said rectification element, one of said connection means for said rectification element being resilient to allow for expansion and contraction relative to said heat sink structure, and means coupled between a given portion of said one of said connection means and said heat sink structure to hermetically seal said rectification element.

19. A semiconductor device adapted to have expansion and contraction characteristic during use comprising a rectification element, a heat sink structure supporting said rectification element, input connection means coupled to said rectification element to apply an alternating signal thereto, output connection means coupled to said rectification element, one of said connection means for said rectification element being resilient to allow for expansion and contraction relative to said heat sink structure, and means coupled between one portion of said one of said connection means and said heat sink structure to hermetically seal said rectification element and another portion of said one of said connection means.

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